

ASSESSING THE NATIONAL STREAMFLOW INFORMATION PROGRAM

Committee on Review of the USGS
National Streamflow Information Program

Water Science and Technology Board
Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, N.W. Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by Cooperative Agreement No. 01HQAG0030 between the National Academy of Sciences, U.S. Department of the Interior, and U.S. Geological Survey. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 0-309-09210-8 (Book)

International Standard Book Number 0-309-53197-7 (PDF)

Library of Congress Control Number 2004110889

Assessing the National Streamflow Information Program is available from National Academies Press, 500 Fifth Street, N.W., Lockbox 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, <http://www.nap.edu>

Cover design by Michele De La Menardiere, National Academy Press. Photo of the Quinault River on the Olympic Peninsula, Washington, courtesy of Jim O'Connor, U.S. Geological Survey. Price Lake image courtesy of North Carolina Department of Commerce, Division of Tourism, Film, and Sports Development, http://www.visitnc.com/media/media_images.asp.

Copyright 2004 by the National Academy of Sciences. All rights reserved.

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Wm. A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Wm. A. Wulf are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

**COMMITTEE ON REVIEW OF THE USGS
NATIONAL STREAMFLOW INFORMATION PROGRAM**

DAVID R. MAIDMENT, *Chair*, The University of Texas, Austin
A. ALLEN BRADLEY, JR., University of Iowa, Iowa City
BENEDYKT DZIEGIELEWSKI, Southern Illinois University, Carbondale
(through December 31, 2002)
RICHARD HOWITT, University of California, Davis
N. LEROY POFF, Colorado State University, Fort Collins
KAREN L. PRESTEGAARD, University of Maryland, College Park
STUART S. SCHWARTZ, Cleveland State University, Cleveland
DONALD I. SIEGEL, Syracuse University, Syracuse, New York
MARY W. STOERTZ, Ohio University, Athens
DAVID G. TARBOTON, Utah State University, Logan
KAY D. THOMPSON, Washington University, St. Louis, Missouri

Staff

WILLIAM S. LOGAN, Project Director
ANITA A. HALL, Program Associate
DIONNE PRINGLE, Anderson Intern

Editor

FLORENCE POILLON

WATER SCIENCE AND TECHNOLOGY BOARD

RICHARD G. LUTHY, *Chair*, Stanford University, Stanford, California
JOAN B. ROSE, *Vice Chair*, Michigan State University, East Lansing
RICHELLE M. ALLEN-KING, State University of New York at Buffalo
GREGORY B. BAECHER, University of Maryland, College Park
KENNETH R. BRADBURY, Wisconsin Geological and Natural History
Survey, Madison
JAMES CROOK, Water Reuse Consultant, Norwell, Massachusetts
EFI FOUFOULA-GEORGIOU, University of Minnesota, Minneapolis
PETER GLEICK, Pacific Institute for Studies in Development, Environ-
ment, and Security, Oakland, California
JOHN LETEY, JR., University of California, Riverside
CHRISTINE L. MOE, Emory University, Atlanta, Georgia
ROBERT PERCIASEPE, National Audubon Society, Washington, D.C.
JERALD L. SCHNOOR, University of Iowa, Iowa City
LEONARD SHABMAN, Virginia Polytechnic Institute and State Univer-
sity, Blacksburg
R. RHODES TRUSSELL, Trussell Technologies, Inc., Pasadena, California
KARL K. TUREKIAN, Yale University, New Haven, Connecticut
HAME M. WATT, Independent Consultant, Washington, D.C.
JAMES L. WESCOAT, JR., University of Illinois at Urbana-Champaign

Staff

STEPHEN D. PARKER, Director
LAURA J. EHLERS, Senior Program Officer
JEFFREY W. JACOBS, Senior Program Officer
WILLIAM S. LOGAN, Senior Program Officer
LAUREN E. ALEXANDER, Program Officer
MARK C. GIBSON, Program Officer
STEPHANIE E. JOHNSON, Program Officer
M. JEANNE AQUILINO, Financial and Administrative Associate
ELLEN A. DE GUZMAN, Research Associate
PATRICIA JONES KERSHAW, Study/Research Associate
ANITA A. HALL, Program Associate
DOROTHY K. WEIR, Senior Program Assistant

Preface

This report is a product of the Committee on Review of the USGS National Streamflow Information Program. This committee was formed in response to discussions held between the U.S. Geological Survey (USGS) and the National Research Council (NRC) Committee on USGS Water Resources Research. The committee works under the auspices of the Water Science and Technology Board of the National Research Council.

Streamflow data and information is an aspect of water science that profoundly affects people's lives. Flood forecasting and drought management; water supply for agriculture, industry, and cities and towns; maintaining instream flows for game fish and other aquatic species and for canoeing and kayaking; and enforcing legal agreements between states and nations—all depend on the availability of high-quality information about the water elevation and discharge of our rivers and streams.

The U.S. Geological Survey is the primary federal agency charged with acquisition and quality control of raw data and its transformation into usable information. Users range from local consultants and municipalities to whitewater rafters, and from academic institutions to federal agencies such as the U.S. Army Corps of Engineers (USACE) and members of Congress. The water resources discipline of the USGS has more than a century of experience in streamgaging. However, societal needs change, science and technology move forward, and the USGS has evolved as well. For example, satellite data transmission, Doppler radar for precipitation estimates, and improvements in flood forecast models have combined to make USGS streamflow data much more valuable for flood forecasting than in the past.

This report concerns the National Streamflow Information Program (NSIP). The NSIP itself was proposed by the USGS to Congress in 1999. Although the gages that comprise it are not new—some of them have been

around for half a century or more—the concept of a network of gages, other kinds of data sources, and integrated research designed to meet *national* needs is new. The USGS therefore asked the NRC to provide feedback on the nascent program.

The committee heard the first presentations on this topic in October 2001. During the next 24 months, the committee met with numerous experts from within and outside the USGS. We are particularly grateful for the assistance of Edmund D. (Ned) Andrews (USGS), Gregor T. Auble (USGS), Jerad D. Bales (USGS), Thomas R. Carroll (National Weather Service), John E. Costa (USGS), Robert M. Hirsch (USGS), Robert B. Jacobson (USGS), Joseph L. Jones (USGS), Matthew C. Larsen (USGS), Daniel R. Luna (National Weather Service), Gail E. Mallard (USGS), Ronald C. Mason (USACE), Gary P. McDevitt (National Weather Service), J. Michael Norris (USGS), Jim E. O'Connor (USGS), Harold H. Opitz (National Weather Service), and J. Dungan Smith (USGS). Committee members then drafted individual contributions and deliberated as a group to achieve consensus on the content of this report.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making its published report as sound as possible and will ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We wish to thank the following individuals for their review of this report:

J. David Allan, University of Michigan
Roger C. Bales, University of California, Merced
Lawrence E. Band, University of North Carolina-Chapel Hill
Kaye Brubaker, University of Maryland
Emery T. Cleaves, Maryland Geological Survey
Katherine K. Hirschboeck, University of Arizona
Marc Ribaud, U.S. Department of Agriculture-Economic Research Service

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Dr. M. Gordon "Reds"

Wolman, of Johns Hopkins University. Appointed by the National Research Council, Dr. Wolman was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

This committee is not the first to comment on the NSIP program and will likely not be the last. We do hope that some of the ideas generated in this report will stimulate further discussions that must take place, not only within the USGS, but also with congressional staff, state and federal agencies, and other generators and users of streamflow data and information. We trust that these discussions will lead to new and better ways to integrate this information into the human and natural world.

David R. Maidment, *Chair*
Committee on Review of the USGS
National Streamflow Information Program

Contents

EXECUTIVE SUMMARY	1
1 INTRODUCTION	13
The National Streamflow Information Program, 15	
Statement of Task, 17	
Organization and Content of this Report, 18	
2 GAGING THE NATION'S STREAMS	19
A History of the Study of Rivers at the USGS, 19	
What Is a Gaging Site, 26	
The NSIP Gaging Network, 32	
Role of Other Agencies in Supporting Streamgaging, 32	
Streamflow Network Design in Other Countries, 33	
Value of a National Streamflow Information Program, 39	
Rationale for Federal Support, 44	
Summary, 46	
3 SELECTION OF NSIP BASE GAGE LOCATIONS	47
The Five Criteria for Siting NSIP Streamgages, 49	
Assessment of the Distribution of Gage Site Locations, 61	
Summary, 66	
4 STREAMFLOW NETWORK DESIGN	68
Statistical Models, 69	
Coverage Models, 78	
The NSIP Network as a Coverage Model, 83	
Recommendations of the Interstate Council on Water Policy, 84	

	Network Design Goals: Contrasting NSIP with State-Designed Streamflow Networks, 89	
	NSIP Network Design: From Data to Information, 92	
	Summary, 98	
5	STREAMFLOW INFORMATION	100
	Intense Data Collection During Floods and Droughts, 101	
	Regional and National Streamflow Assessments, 106	
	Enhanced Information Delivery, 109	
	Methods Development and Research, 114	
	Summary, 118	
6	CONTRIBUTIONS OF NSIP TO RIVER SCIENCE	120
	River Science Opportunities Created by the NSIP, 121	
	Information Needs for River Science, 130	
	Summary, 134	
7	SUMMARY AND CONCLUSIONS	135
	Rationale for Federal Support of a National Network, 136	
	The Base Gage Network, 137	
	Other NSIP Components, 142	
	Adaptive Management, 144	
	River Science, 145	
	REFERENCES	146
	APPENDIX A	
	Biographical Sketches of Members of the Committee on Review of the USGS National Streamflow Information Program	161